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HYDROGEN-OXYGEN ELECTROLYTIC REGENERATIVE FUEL CELLS

Prepared for

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Contract NAS 3-2781

EOS Report 4110-M-5

10 February 1964

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GPO PRICE \$ _____
OTS PRICE(S) \$ _____

Hard copy (HC) \$1.00

Microfiche (MF) .50

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1. INTRODUCTION

This report reviews the progress made on the development of a rechargeable fuel cell (NAS Contract 3-2791) during the month of January 1964. Fabrication of the component parts of the nominal 75 watt model was completed, the unit was assembled and preliminary tests were carried out.

2. TECHNICAL DISCUSSION

This section outlines the progress made in the development of the unit.

2.1 Fabrication

Two problems arose during the final stages of fabrication and caused some delay in the program. The most critical problem was found to be that of nickel plating of the magnesium components of the assembly. The two local plating firms recommended by Dow Metal Products, Inc. were found to be reluctant to attempt to nickel plate these parts via the electroless nickel process. This reluctance was attributed to the possibility of a "burn out", i.e., the chemical attack of the magnesium by the plating solutions. The problem was said to be very critical for particular parts (cell separators and end plates) because of the numerous small gas passageways and a few "dead end" holes. Alternative methods of coating the parts were considered, but were deemed less reliable. It was finally decided to proceed with the electroless nickel plating on a "best effort basis". All but one of the parts, the hydrogen and plate, were successfully plated without any "burn outs". There was no burn out on this particular part, but the vendor stopped the plating in the early stages when he noted a small crack in one of the welds.

Further inspection of the part revealed several small cracks in the weld. These faults were not observable in the initial inspection

of the part and may have appeared due to an etching of the metal surface while in the plating solution. The part was subsequently rewelded, and successfully nickel plated without burn out. The small gas passages on this part were masked off, and received no plating. The passages were, however, subsequently coated with a thin layer of epoxy resin.

2.2 Final Inspection and Proof Testing

Critical dimensions of all parts were checked and found to be within specified tolerances. Continuity of all gas passages was checked by forcing air through each port. Careful inspection of the nickel plating revealed a few pin holes which were subsequently covered with epoxy resin. The unit was assembled with the two end plates inside the gas cylinders and was proof tested at 500 psig. The test consisted of filling the unit with water and then applying nitrogen gas at this pressure for 1/2 hour. The unit successfully withstood the test and there was no deformation of any parts.

2.3 Assembly and Start Up

The nickel screen and catalyzed nickel electrodes were first spot welded to the cell separators. The electrolyte bed was prepared by adding the required amount of KOH solution to the asbestos discs. The cell stack was subsequently assembled, and compressed by tightening the twelve insulated bolts on its periphery. A torque wrench was employed in this phase of the assembly to obtain uniform compression. The gas ports leading to the bellows pressure equalizer were blocked off for initial tests in the "primary mode" of operation. The complete unit was then installed inside the gas containment cylinders. The twelve insulated bolts on the flanges of the gas cylinders were uniformly tightened, and the unit was readied for test.

Residual air within the assembly was replaced by pure H_2 and O_2 by a purging process. This process consisted of pressurizing the cylinders with their respective gases, and then venting to the atmosphere several times. The gases were admitted to and released from the cylinders simultaneously, and very slowly with the aid of needle valves. A differential pressure gage, connected across the cell, was employed to keep the

differential pressures to a valve less than 0.1 psig during the above purging operation. After completion of this operation the unit was ready for electrical testing.

2.4 Preliminary Testing

The initial test consisted of an operation in the "quasi secondary" mode of operation as described in the second quarterly report. The test was carried out with one cell inside the assembly. The initial voltage-current characteristics and cell impedance measurements indicated a relatively high internal cell resistance of .035 ohms, at 25°C. Improved electrical contacts were installed, and the resistance was reduced to the acceptably low value of .021 ohms at 25°C which becomes .003 ohms at 67°C.

Subsequent tests were carried out in the same manner as above with six cells inside the assembly. The impedance of the complete assembly was .048 ohms at 37°C. Preliminary charge-discharge characteristics for a 6-cell unit are given below. The charge cycle was performed at design current and duration. However, due to the off design temperature and reduced gas pressure, the discharge cycle was performed at below rated current for an extended duration to simulate the rated amp-hours. Later tests will include operation over the range of temperatures, pressures and loads of interest.

Charge at 9.6 amps with internal temperature near 50°C and 1 atm gas pressure.

Time (min.)	Volts
0	8.8
20	9.8
40	9.9
60	10.0
76	10.1

Discharge at 8 amps with internal temperature near 50°C and 100 psig gas pressures.

Time (min.)	Volts
0	4.8
25	4.9
50	4.9
75	4.9
91	4.9

3. PLANS FOR FEBRUARY

Cycle tests will be continued in the quasi secondary mode of operation as above. The tests will be carried out over a range of charge and discharge rates and over a range of ambient temperatures. The unit will then be instrumented to give individual cell voltages and temperatures and will be cycled in the true secondary mode of operation.

4. FINANCIAL STATEMENT

Manhours and Dollar Expenditure for Period Jan. 1-Feb. 1, 1964

Direct Labor Hours	\$ 555.5
Direct Labor Dollars	2,595.21
Purchases and Commitments	783.48
Total Dollar Expenditure	\$ 8,468.56